**MATLAB Basics for Psych 4450 - Part 3**

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If you have any questions about MATLAB or the class, feel free to email me, post to the #matlab channel on Slack (everyone can benefit!), direct message me on Slack, or set up a time here <https://calendly.com/aahanabajra> to chat via Zoom.

If you run into issues or have specific questions about this document, you can also make a comment and I will try to update it to address your question.

In this part of the MATLAB Basics guide, we will focus on using MATLAB to understand the numbers behind the fMRI images. We will explore some ways in which you can **quantify and visualize data quality**.

One of the challenges faced by neuroimaging researchers is ways to deal with **motion in the data**. If you are conducting the experiment yourself, you may have an idea about the subjective experience of individual subjects in regards to the imaging session (example: participant reports to you that they fell asleep in between a task that caused them to move). However, when dealing with publicly available datasets, these kinds of information might not be included. There are many types of physiological or technical reasons that can cause the data to be noisy, but that is beyond the scope of this guide. It is always good practice to report data quality metrics along with results so that the appropriate data cleaning or de-noising methods can be applied during post-processing. Below are some helpful papers by Jonathan Power that talk about motion correction in detail. Most of the metrics included in this guide are also based on papers by Power et.al.

Power, J. D. (2017). A simple but useful way to assess fMRI scan qualities. *Neuroimage*, *154*, 150-158. [Paper Pdf](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5296400/pdf/nihms817852.pdf)

Power, J. D., Schlaggar, B. L., & Petersen, S. E. (2015). Recent progress and outstanding issues in motion correction in resting-state fMRI. *Neuroimage*, *105*, 536-551. [Paper Pdf](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4262543/pdf/nihms640744.pdf)

Power, J. D., Barnes, K. A., Snyder, A. Z., Schlaggar, B. L., & Petersen, S. E. (2012). Spurious but systematic correlations in functional connectivity MRI networks arise from subject motion. *Neuroimage*, *59*(3), 2142-2154. [Paper Link](https://www.sciencedirect.com/science/article/pii/S1053811911011815?casa_token=Gcd0HXUc58AAAAAA:Ck5vqQfMaqLDrb5L_-xnm17K-5ZFBesy3dKKvi1-p8JTBtqgUo81o3ZkpulloGbGf2DEjfU)

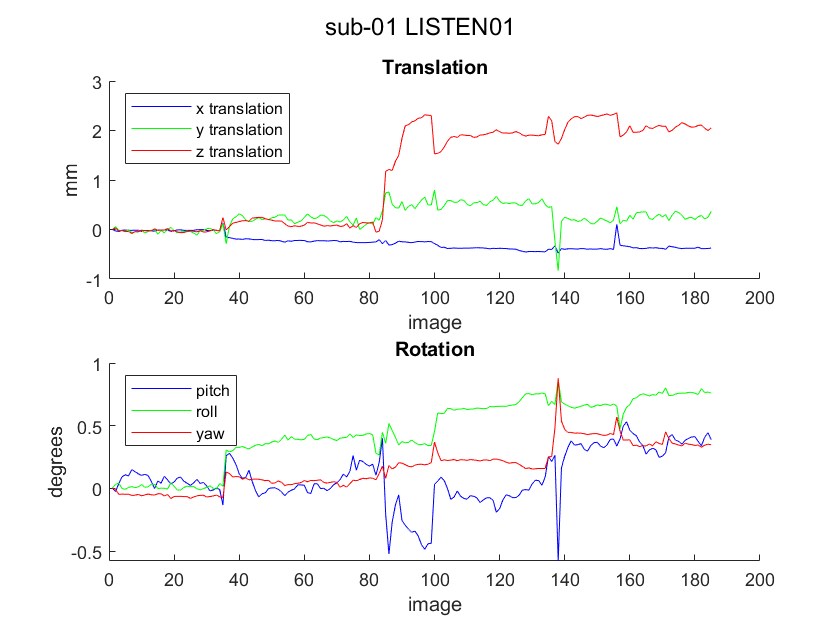
I will talk about a few metrics below that are easy to implement and also tie in with the material that we have discussed in class. By the end of this guide, you will have the tools to include some of these data quality metrics for your own data.

Topics:

* Motion summary plots **(plot\_rp.m)**
* Framewise Displacement (FD) **(plot\_FD.m)**
* Global Signal **(plot\_GS.m)**
* Timeseries visualization **(plot\_timeseries.m)**

## Motion Summary Plots

After the realignment step in the preprocessing pipeline, SPM generates a figure that consists of a summary of the realignment parameters; translation and rotations in the x, y, and z directions. The rotations are also commonly known as roll, pitch, and yaw. The figure below shows a frame by frame movement registered for the participant in the indicated directions. The x-axis in the plot below can be understood as a frame/image/snapshot of the brain at a given time point.

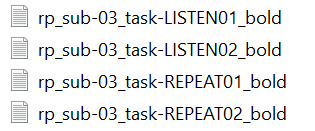


The lines in the above figure correspond to movement as shown in the figures below.

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| --- | --- |

[The figure on the right is from, <http://www.newbi4fmri.com/tutorial-4-motion>. It has helpful resources for beginners in fMRI data processing. The only catch is that the tutorials here use BrainVoyager instead of SPM. But could be a great resource for conceptual explanations. Here’s another resource that uses SPM - <https://andysbrainbook.readthedocs.io/en/latest/SPM/SPM_Overview.html> ]

Once the realignment step is completed, you will have the necessary rp\_ files (see below) to plot the above figure on your own. The **plot\_rp.m** code uploaded on Canvas shows you how to plot the above motion summary figure outside of SPM using these text files.

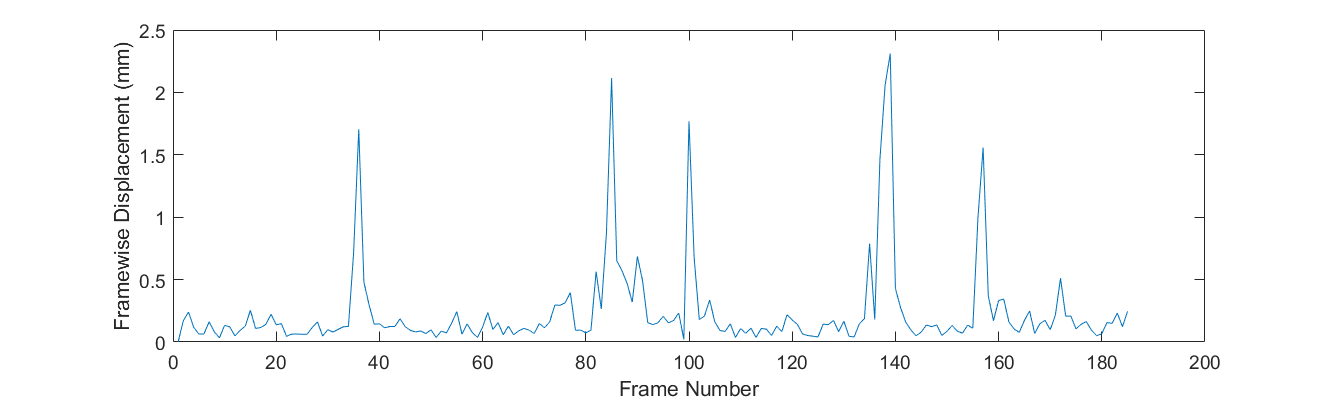


Each of these text files consists of 6 columns of numbers that represent the translation and rotations for each time point in a given session. The translation is in mm whereas the rotation values are in radians. We convert this to degrees when plotting.

## 

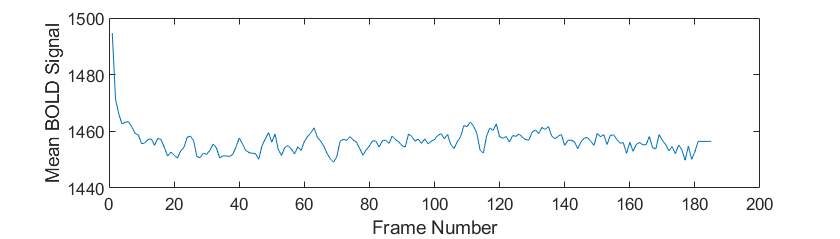
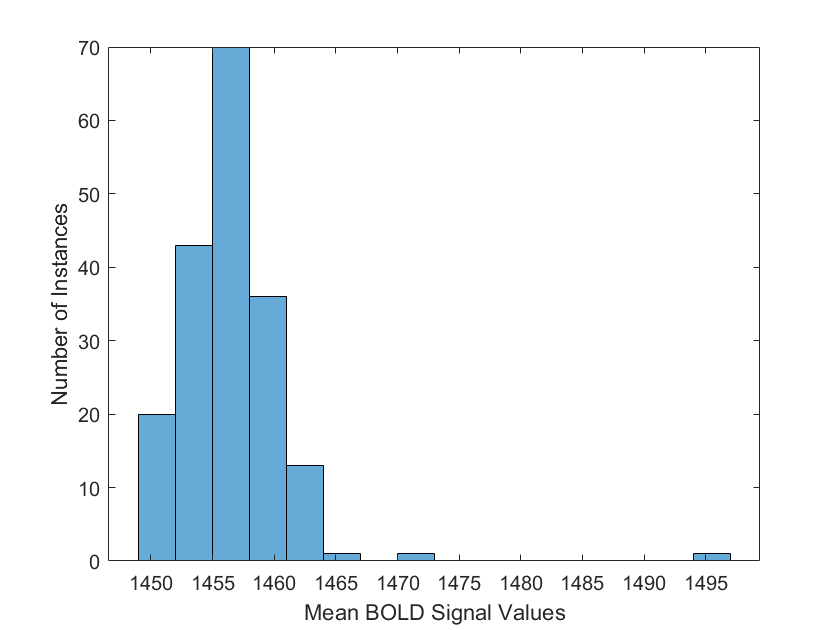
## Framewise Displacement (FD)

FD refers to the sum of the absolute difference between subsequent frames in the timeseries for each of the six realignment parameters. The following figure shows the FD for one of the sessions in the data. Since the rotation parameters are listed as radians, we first convert it to distances so that all six parameters can be added. We do this by computing the arc length displacement on the surface of the sphere with a radius of 50 mm (an approximate mean distance from the cerebral cortex to the center of the head) Power et.al 2012.



## Global Signal

It refers to the overall signal intensity across time for any given subject. Obtaining a measure of the global signal helps to identify frames where motion affected all of the voxels in the brain to an extent that could be harmful to the data if unaddressed. Artifacts due to respiration and motion are often visible in these plots. The histogram on the right summarizes the global signal plot on the left.

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## Timeseries visualization

We have already come across plots of a couple of timeseries (a certain value that varies across equal intervals of time). Plotting the **time course of a single voxel** is one of the most simple yet effective ways of gaining an intuition of your data. The code currently does not account for conversion into MNI coordinate but I am including this here to give you a sense of the 4D nature of the data that you are dealing with. The following plot shows the change in the BOLD signal in a single voxel over time.

